A BIOLOGICAL ASSESSMENT OF SITES IN THE YAAK RIVER DRAINAGE:
LINCOLN COUNTY, MONTANA
Project TMDL – K03

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A report to

The Montana Department of Environmental Quality
Planning, Prevention and Assistance Division
Helena, Montana
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by

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INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected in August 2003 from sites in the Yaak River drainage, Lincoln County, Montana. Aquatic invertebrate assemblages were sampled by personnel of the Montana Department of Environmental Quality (MT DEQ). All of the study sites lie within the Northern Rockies ecoregion (Woods et al. 1999).

A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is "...a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1996). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998a). The first of these is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied enhances the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat measures and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998a) has recently studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion, and has recommended a battery of metrics applicable to the montane ecoregions of western Montana. This metric battery has been shown to be sensitive to impairment, related to measures of habitat integrity, and consistent over replicated samples.

METHODS

Samples were collected in August 2003 by MT DEQ and Land and Water Consulting personnel. Sample designations and site locations are indicated in Tables 1a and 1b, and approximate locations are illustrated in Figure 1. The site selection and sampling method employed were those recommended in the MT DEQ Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998). Aquatic invertebrate samples were delivered to Rhithron Associates, Inc., Missoula, Montana, for laboratory and data analyses.

In the laboratory, the MT DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample, when possible. Organisms were identified to the lowest possible taxonomic levels consistent with MT DEQ protocols.

Table 1a. Sample designations and locations. Sites are listed by drainage in upstream-to-downstream order. The Yaak River drainage, August 2003.

Site	Sampling Date	Station ID	Activity ID	Location Description	Latitude/ Longitude
East, North, and West Fork drainage					
YAKER01	8/14/03	K03YAKER01	03-C259-M	YAAK RIVER UPPER EAST FORK	48°55'48"/115°27' 0"
YAKER02	8/14/03	K03YAKER02	03-C260-M	YAAK RIVER EAST FORK ABOVE BASIN	48°56'24"/115°28' 48"
BASNC02	8/14/03	K03BASNC02	03-C258-M	BASIN CREEK EAST FORK	48°54'43.92"/115°28' 29.34"
YAKER03	8/14/03	K03YAKER03	03-C261-M	YAAK RIVER EAST FORK BELOW BLACKTAIL	48°56'24"/115°32' 24"
YAKNF01	8/13/03	K03YAKNF01	03-C262-M	YAAK RIVER NORTH FORK ABOVE HWY BR	48°58'12"/115°37' 12"
YAKWR01	8/16/03	K03YAKWR01	03-C270-M	YAAK RIVER WEST FORK YAAK	48°55'48"/115°54' 36"
YAKWR02	8/13/03	K03YAKWR02	03-C263-M	YAAK RIVER WEST FORK U/S OF FALLS	48°56'24"/115°43' 48"
LAPC01	8/13/03	K03LAPC01	03-C265-M	LAP CREEK @ MOUTH	48°52'48"/115°39' 36"
South Fork drainage					
YAKSR03	8/15/03	K03YAKSR03	03-C268-M	YAAK RIVER SOUTH FORK BELOW SMOOT	48°43'12"/115°38' 24"
YAKSR01	8/13/03	K03YAKSR01	03-C264-M	YAAK RIVER SOUTH FORK MID SECTION	48°47'24"/115°39' 36"
BEVRC01	8/13/03	K03BEVRC01	03-C255-M	BEAVER CREEK	48°48'36"/115°40'12"
YAKSR02	8/13/03	K03YAKSR02	03-C254-M	YAAK RIVER SOUTH FORK BELOW BEAVER	48°49'12"/115°40'48"

Table 1b. Sample designations and locations. Sites are listed by drainage in upstream-to-downstream order. The Yaak River drainage, August 2003.

Site	Sampling Date	Station ID	Activity ID	Location Description	Latitude/ Longitude
PETEC02	8/16/03	K03PETEC02	03-C272-M	PETE CREEK ABOVE BEETLE	48°54'0"/115°48' 36"
PETEC01	8/15/03	K03PETEC01	03-C267-M	PETE CREEK BELOW HENSLEY	45°57'4"/113°44' 37"
SPDUC01	8/12/03	K03SPDUC01	03-C252-M	SPREAD CREEK UPPER SECTION ABOVE ROAD INFLUENCE	48°54'36"/115°59' 24"
SPDMC01	8/12/03	K03SPDMC01	03-C253-M	SPREAD CREEK MIDDLE	48°52'12"/115°57' 0"
MEDOC01	8/13/03	K03MEDOC01	03-C257-M	MEADOW CREEK LOWER U/S OF NF MEADOW	48°46'48"/115°55' 48"
GRIZC01	8/12/03	K03GRIZC01	03-C256-M	GRIZZLY CREEK	48°44'24"/115°48' 36"
SVNTC02	8/12/03	K03SVNTC02	03-C250-M	17 MILE CREEK MAINSTEM D/S OF HEMLOCK	48°37'48"/115°43' 12"
SVNTC01	8/12/03	K03SVNTC01	03-C251-M	17 MILE NORTH FORK	48°39'36"/115°45' 36"

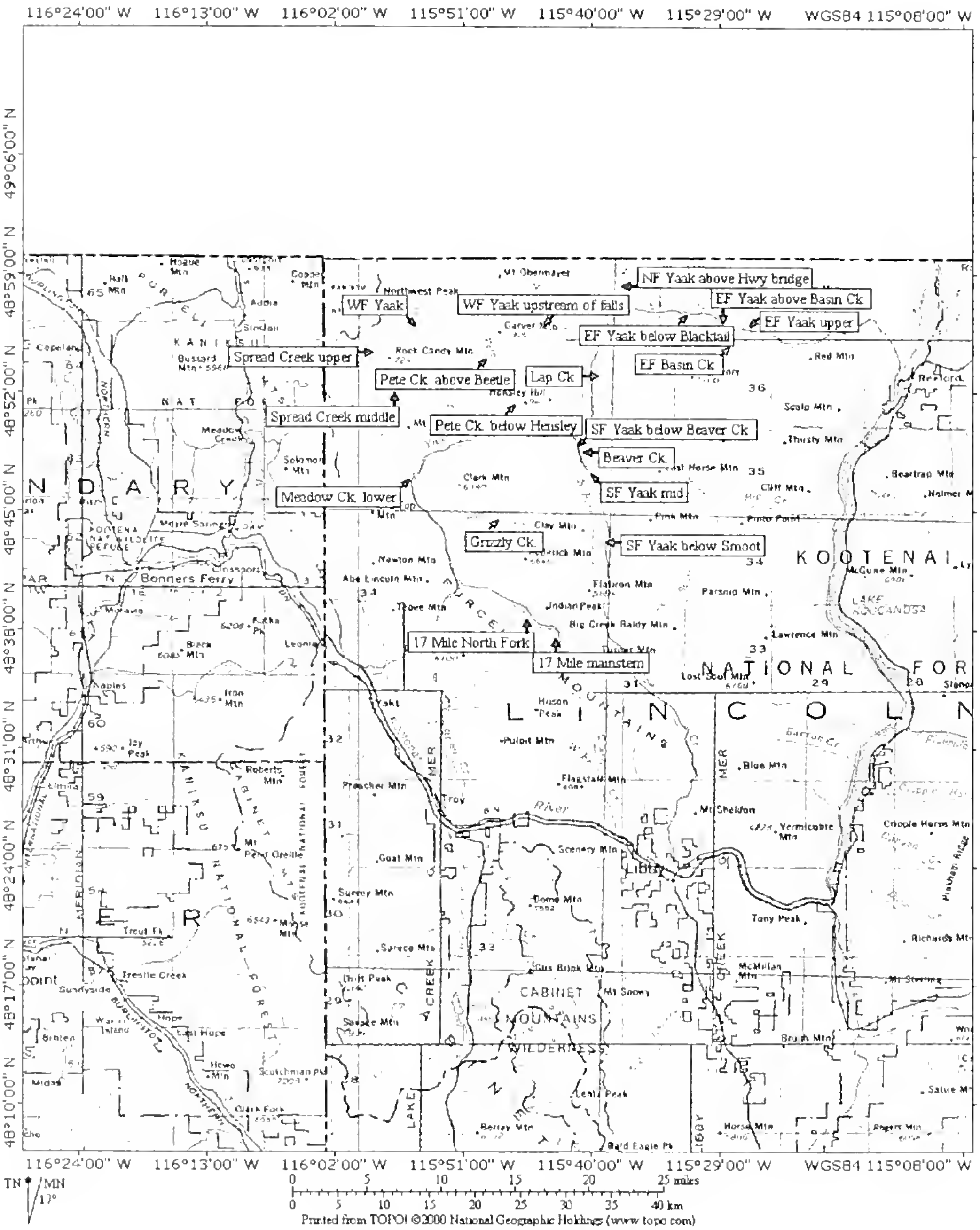


Figure 1. Approximate locations of sampled sites. Yaak River watershed, August 2003.

To assess aquatic invertebrate communities in this study, a multimetric index developed in previous work for streams of western Montana ecoregions (Bollman 1998a) was used. Multimetric indices result in a single numeric score, which integrates the values of several individual indicators of biologic health. Each metric used in this index was tested for its response or sensitivity to varying degrees of human influence. Correlations have been demonstrated between the metrics and various symptoms of human-caused impairment as expressed in water quality parameters or instream, streambank and stream reach morphologic features. Metrics were screened to minimize variability over natural environmental gradients, such as site elevation or sampling season, which might confound interpretation of results (Bollman 1998a). The multimetric index used in this report incorporates multiple attributes of the sampled assemblage into an integrated score that accurately describes the benthic community of each site in terms of its biologic integrity. In addition to the metrics comprising the index, other metrics shown to be applicable to biomonitoring in other regions (Kleindl 1995, Patterson 1996, Rossano 1995) were used for descriptive interpretation of results. These metrics include the number of "clinger" taxa, long-lived taxa richness, the percent of predatory organisms, and others. They are not included in the integrated bioassessment score, however, since their performance in western Montana ecoregions is unknown. However, the relationship of these metrics to habitat conditions is intuitive and reasonable.

The six metrics comprising the bioassessment index used in this study were selected because, both individually and as an integrated metric battery, they are robust at distinguishing impaired sites from relatively unimpaired sites (Bollman 1998a). In addition, they are relevant to the kinds of impacts that are present in the Yaak River drainage. They have been demonstrated to be more variable with anthropogenic disturbance than with natural environmental gradients (Bollman 1998a). Each of the six metrics developed and tested for western Montana ecoregions is described below.

1. **Ephemeroptera (mayfly) taxa richness.** The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific conductance and toxic chemicals. Few mayfly species are able to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.
2. **Plecoptera (stonefly) taxa richness.** Stoneflies are particularly susceptible to impairments that affect a stream on a reach-level scale, such as loss of riparian canopy, streambank instability, channelization, and alteration of morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.
3. **Trichoptera (caddisfly) taxa richness.** Caddisfly taxa richness has been shown to decline when sediment deposition affects their habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.
4. **Number of sensitive taxa.** Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998a).
5. **Percent filter feeders.** Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment material, from the water column by means of a variety of adaptations, such as silken nets or hairy appendages. In forested montane streams, filterers are expected to occur in insignificant numbers. Their abundance increases when canopy cover is lost and when water temperatures increase and the accompanying growth of filamentous algae occurs. Some filtering organisms, specifically the Arctopsychid caddisflies (*Arctopsyche* sp. and

Parapsyche spp.) build silken nets with large mesh sizes that capture small organisms such as chironomids and early-instar mayflies. Here they are considered predators, and, in this study, their abundance does not contribute to the percent filter feeders metric.

6. Percent tolerant taxa. Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges as well as in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values were transformed into a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery.

Table 2. Metrics and scoring criteria for bioassessment of streams of western Montana ecoregions (Bollman 1998a).

	Score			
Metric	**3**	**2**	**1**	**0**
Ephemeroptera taxa richness	> 5	5 - 4	3 – 2	< 2
Plecoptera taxa richness	> 3	3 - 2	1	0
Trichoptera taxa richness	> 4	4 - 3	2	< 2
Sensitive taxa richness	> 3	3 - 2	1	0
Percent filterers	0 – 5	5.01 - 10	10.01 – 25	> 25
Percent tolerant taxa	0 – 5	5.01 - 10	10.01 – 35	> 35

The total bioassessment score for each site was expressed in terms of use-support. Criteria for use-support designations were developed by MT DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

Table 3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis 1998).	
% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table 3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989).	
% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

In this report, certain other metrics were used as descriptors of the benthic community response to habitat or water quality but were not incorporated into the bioassessment metric battery, either because they have not yet been tested for reliability in streams of western Montana, or because results of such testing did not show them to be robust at distinguishing impairment, or because they did not meet other requirements for inclusion in the metric battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman 1998b). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water quality conditions in Montana (Bukantis 1998). Ordination studies of the benthic fauna of Montana's foothill prairie streams showed that there is a correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998a). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).
- Taxa richness. This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- Percent predators. Aquatic invertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.

- Number of "clinger" taxa. So-called "clinger" taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Aquatic invertebrate "clingers" are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are included in this group of taxa. Expected "clinger" taxa richness in unimpaired streams of western Montana is at least 14 (Bollman 1998b).
- Number of long-lived taxa. Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman 1998b).

RESULTS

Bioassessment

Figure 2 summarizes bioassessment scores for aquatic invertebrate communities sampled at the 20 sites in this study. Tables 4a, 4b and 4c itemize each contributing metric and show individual metric scores for each site. Tables 3a and 3b above show criteria for use-support categories recommended by MT DEQ (Bukantis 1998) and impairment classifications (Plafkin et al. 1989). Macroinvertebrate taxa lists, metric results and other information for each sample are given in the Appendix.

When this bioassessment method is applied to these data, scores suggest that 18 of the sampled sites were essentially non-impaired and fully supported their designated uses. These sites were: East Fork Yaak River upper (YAKER01), East Fork Yaak River above Basin Creek (YAKER02), East Fork Basin Creek (BASNC02), East Fork Yaak River below Blacktail Creek (YAKER03), West Fork Yaak River (YAKWR01), Lap Creek at mouth (LAPC01), South Fork Yaak River below Smoot Creek (YAKSR03), South Fork Yaak River midsection (YAKSR01), Beaver Creek (BEVRC01), South Fork Yaak River below Beaver Creek (YAKSR02), Pete Creek above Beetle Creek (PETEC02), Pete Creek below Hensley (PETEC01), Spread Creek upper section (SPDUC01), Spread Creek middle (SPDMC01), Meadow Creek lower (MEDOC01), Grizzly Creek (GRIZC01), Seventeen Mile Creek mainstem (SVNTC02), and North Fork Seventeen Mile Creek (SVNTC01). Two sites were slightly impaired and partly supported uses. These were North Fork Yaak River above Highway bridge (YAKNF01) and West Fork Yaak River upstream of falls (YAKWR02).

Aquatic invertebrate communities

Interpretations of biotic integrity in this report are made without reference to results of habitat assessments, or any other information about the sites or watersheds that may have accompanied the invertebrate samples. Interpretations are based entirely on: the taxonomic and functional composition of the sampled invertebrate assemblages; the sensitivities, tolerances, physiology, and habitus information for individual taxa gleaned from the writer's research; the published literature, and other expert sources; and on the performance of bioassessment metrics, described earlier in the report, which have been demonstrated to be useful tools for interpreting potential implications of benthic invertebrate assemblage composition.

To summarize similarities between invertebrate assemblages in this study, a sites-by-taxa matrix was constructed, using the abundance of each taxon at each site. Principal Components Analysis (PCA) was used to generate a graphical ordination of the data. Ordination produces a plot in which similar assemblages are graphed close together, and dissimilar assemblages are far apart. Figure 3 gives the results of the PCA.

Figure 2. Total bioassessment scores compared among sites in the Yaak River Drainage, August 2003. The revised bioassessment method (Bollman 1998) was used to determine scores. Scores are reported as the percent of maximum possible score.

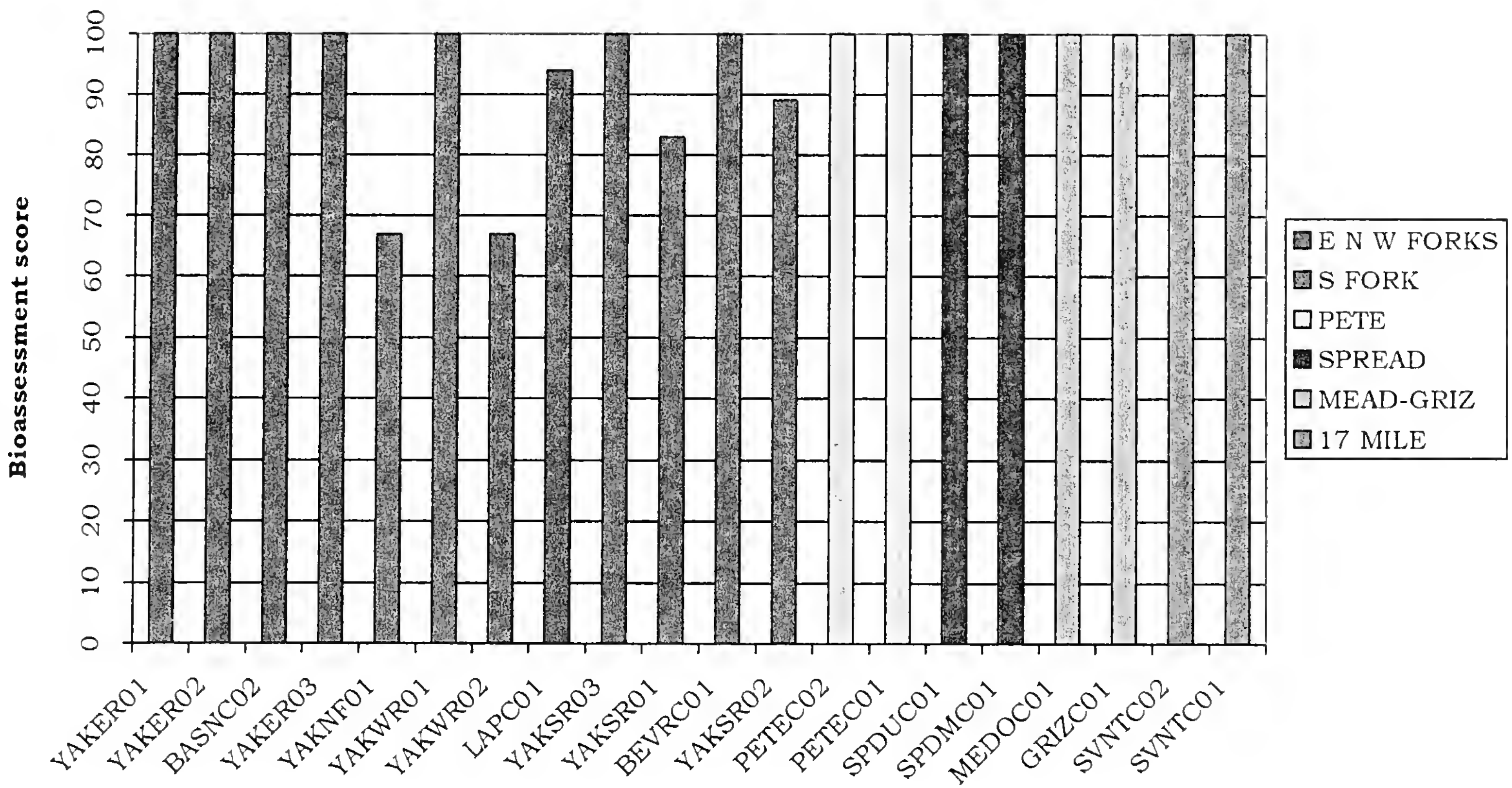


Table 4a. Metric values, scores, and bioassessments for sites in the Yaak River Drainage, August 2003. The revised bioassessment method (Bollman 1998) was used to determine scores. Site locations are given in Table 1.

	SITES							
	East, North, and West Fork drainage							
METRICS	YAKER 01	YAKER 02	BASNC 02	YAKER 03	YAKNF 01	YAKWR 01	YAKWR 02	LAPC 01
				METRIC VALUES				
Ephemeroptera richness	10	13	12	10	6	10	5	9
Plecoptera richness	5	6	6	5	6	8	3	7
Trichoptera richness	6	7	8	8	9	6	8	5
Number of sensitive taxa	10	11	11	9	3	13	2	9
Percent filterers	0.32	1.27	1.52	6.49	11.99	0.32	20.59	0
Percent tolerant taxa	0	0	0	0.59	41.78	0	8.50	5.29
				METRIC SCORES				
Ephemeroptera richness	3	3	3	3	3	3	2	3
Plecoptera richness	3	3	3	3	3	3	2	3
Trichoptera richness	3	3	3	3	3	3	3	3
Number of sensitive taxa	3	3	3	3	2	3	2	3
Percent filterers	3	3	3	3	1	3	1	3
Percent tolerant taxa	3	3	3	3	0	3	2	2
TOTAL SCORE (max.=18)	18	18	18	18	12	18	12	17
PERCENT OF MAX.	**100%**	**100%**	**100%**	**100%**	**67%**	**100%**	**67%**	**94%**
Impairment classification*	**NON**	**NON**	**NON**	**NON**	**SLI**	**NON**	**SLI**	**NON**
USE SUPPORT †	**FULL**	**FULL**	**FULL**	**FULL**	**PART**	**FULL**	**PART**	**FULL**

* Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.
† Use support designations: See Table 3a.

Table 4b. Metric values, scores, and bioassessments for sites in the Yaak River Drainage, August 2003. The revised bioassessment method (Bollman 1998) was used to determine scores. Site locations are given in Table 1.

	SITES			
	South Fork drainage			
	YAKSR 03	YAKSR 01	BEVRC 01	YAKSR 02
METRICS	**METRIC VALUES**			
Ephemeroptera richness	8	7	9	9
Plecoptera richness	4	4	5	3
Trichoptera richness	6	6	8	6
Number of sensitive taxa	8	3	9	5
Percent filterers	0	3.68	0.31	6.02
Percent tolerant taxa	0	19.63	1.56	4.68
	METRIC SCORES			
Ephemeroptera richness	3	3	3	3
Plecoptera richness	3	3	3	2
Trichoptera richness	3	3	3	3
Number of sensitive taxa	3	2	3	3
Percent filterers	3	3	3	2
Percent tolerant taxa	3	1	3	3
TOTAL SCORE (max.=18)	18	15	18	16
PERCENT OF MAX.	**100%**	**83%**	**100%**	**89%**
Impairment classification*	**NON**	**NON**	**NON**	**NON**
USE SUPPORT †	**FULL**	**FULL**	**FULL**	**FULL**

* Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.
† Use support designations: See Table 3a.

Table 4c. Metric values, scores, and bioassessments for sites in the Yaak River Drainage, August 2003. The revised bioassessment method (Bollman 1998) was used to determine scores. Site locations are given in Table 1.

	SITES							
	Pete Creek		Spread Creek		Meadow and Grizzly Creeks		17 Mile Creek	
METRICS	PETEC 02	PETEC 01	SPDUC 01	SPDMC 01	MEDOC 01	GRIZC 01	SVNTC 02	SVNTC 01
	METRIC VALUES							
Ephemeroptera richness	8	11	8	9	9	11	10	11
Plecoptera richness	8	9	9	7	7	8	5	6
Trichoptera richness	7	8	5	5	14	9	8	13
Number of sensitive taxa	8	12	12	10	12	15	8	10
Percent filterers	3.19	2.89	0	0	4.41	3.03	0.94	3.70
Percent tolerant taxa	0.64	2.57	0.30	0	0.34	0	3.44	0.67
	METRIC SCORES							
Ephemeroptera richness	3	3	3	3	3	3	3	3
Plecoptera richness	3	3	3	3	3	3	3	3
Trichoptera richness	3	3	3	3	3	3	3	3
Number of sensitive taxa	3	3	3	3	3	3	3	3
Percent filterers	3	3	3	3	3	3	3	3
Percent tolerant taxa	3	3	3	3	3	3	3	3
TOTAL SCORE (max.=18)	18	18	18	18	18	18	18	18
PERCENT OF MAX.	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Impairment classification*	**NON**	**NON**	**NON**	**NON**	**NON**	**NON**	**NON**	**NON**
USE SUPPORT †	**FULL**	**FULL**	**FULL**	**FULL**	**FULL**	**FULL**	**FULL**	**FULL**

* Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.
† Use support designations: See Table 3a.

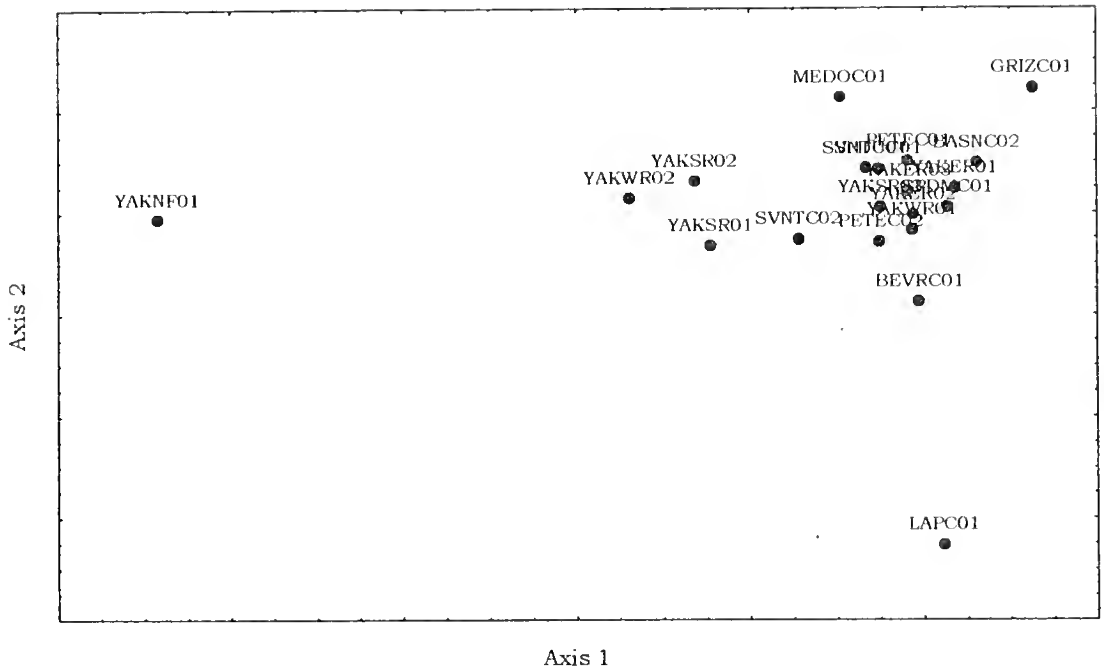


Figure 3. Ordination (Principal Components Analysis) of sampled assemblages from the Yaak River watershed. August 2003.

The ordination illustrates the high degree of similarity of invertebrate assemblages at a large proportion of the sampled sites. Generally, these 16 sites were those that were assessed as non-impaired based on bioassessment scores; scores attained at these locations were either 100% of maximum or, in a single case, 94%. The ordination groups the sites in the right half of the plot. Assemblages at these sites typically include the mayflies *Ameletus* sp., *Cinygmula* sp., *Drunella coloradensis*, *Epeorus deceptivus*, *Epeorus grandis*, and *Rhithrogena* sp. These taxa suggest clean water and fast currents. None were taken in samples from the other 4 sites. Certain stoneflies were collected exclusively at the 16 unimpaired sites: *Doroneuria sp.*, *Megarcys* sp., *Yoraperla brevis*, and *Zapada columbiana*. All of these stoneflies are sensitive taxa, and their presence suggests good reach-scale habitat conditions. The caddisflies in the Rhyacophila Betteni and Brunnea Groups, as well as *Parapsyche elsis* were collected at nearly all of these sites, and were absent from samples collected at the other sites. *Parapsyche elsis* is a sensitive taxon, and all three taxa are "clingers". These sites were likely to be free from fine sediment contamination of benthic habitats. In addition, a majority of these sites supported significant numbers of the turbellarian *Polycelis coronata*. This animal is often associated with groundwater inputs.

The other 4 sampled sites, which exhibited either slight degrees of impairment or some deviation from the ideal condition measured by the individual bioassessment metrics, also had characteristic faunal elements. These sites are represented on the ordination plot by an outlier on the far left side of the graph and a loose cluster of 3 sites near the center. The snipe-fly *Atherix* sp. was only collected at these sites, as was the midge *Cricotopus nostococladius*. The perlid stoneflies *Hesperoperla pacifica* and *Claassenia sabulosa* were exclusive to these locations, as were the caddisflies *Hydropsyche* sp. and *Brachycentrus americanus*. The tolerant elmid beetles *Cleptelmis addenda*, *Optioservus* sp. and *Zaitzevia* sp. were more likely to occur

at these 4 sites than at the 16 unimpaired sites. These taxa suggest somewhat warmer water temperatures and fine particles of organic material in suspension.

East Fork Yaak River and Basin Creek sites

All 4 sites in the East Fork Yaak River (YAKER01, YAKER02, BASNC02, and YAKER03) watershed supported diverse, sensitive, and functional invertebrate assemblages characteristic of minimally impaired montane streams. Low biotic index values (range 1.81 - 2.40) and high mayfly taxa richness values (range 10 – 13) suggest that water quality was excellent at these sites. Cold stenotherm taxa were common in the watershed, and included the stoneflies *Megarcys* sp. and *Zapada columbiana*, and the mayfly *Drunella doddsi*, all of which were present at all 4 locations. Cold, clean water appears to have been characteristic of the drainage.

Both "clingers" (range 20 – 23) and caddisflies (range 6 – 8) were well-represented at each of these locations. These rich faunae suggest that fine sediment did not compromise stony benthic substrate habitats. Overall taxa richness values (range 37 – 46) were high at all sampled sites; this finding, along with high numbers of predator taxa (range 11 – 17) imply that instream habitats were diverse and available. Stonefly taxa richness (range 5 – 6) met expectations in all cases; these insects may be associated with intact reach-scale habitat features. A diverse Plecoptera fauna suggests stable streambanks, functional riparian zones, and natural channel morphology. Long- lived taxa were amply represented at the East Fork Yaak River upper site (YAKER01), at the site below Blacktail Creek (YAKER03), and on Basin Creek (BASNC02). At the East Fork Yaak River site above Basin Creek (YAKER02) only 2 semi-voltine taxa were collected. Adults of the elmid beetle *Heterlimnius* sp. were abundant there, however, which makes it seem likely that conditions favorable to long life cycles had not been catastrophically interrupted there. Each of the invertebrate assemblages collected at these sites included all expected functional elements.

North Fork Yaak River site

The single site sampled on the North Fork Yaak River (YAKNF01) yielded an assemblage that was more tolerant than anticipated. The biotic index value calculated for the sampled animals was 3.57, somewhat higher than expected for a montane stream. The mayfly taxa richness (6), although within expected limits, was among the lower values encountered in this study. Mayflies collected at the site included *Timpanoga hecuba* and *Nixe criddlei*. The appearance of these insects, along with the dearth of cold-stenotherm taxa (3) in the sample, suggest that water temperatures may have been warmer here than at other sites in the study area. The sampled assemblage was dominated by tolerant animals, including the elmids *Cleptelmis addenda*, *Optioservus* sp., and *Zaitzevia* sp.

Abundant "clingers" (21 taxa) and a rich caddisfly fauna (9 taxa) suggest that fine sediment deposition did not impair stony surface habitats. Other instream habitats were likely intact as well, since at least 43 taxa, including 12 predator taxa were supported at the site. Reach-scale habitat features such as streambanks, riparian corridors, and channel morphological elements were probably undisturbed, since stonefly taxa richness (6) was within expectations. Ten semi-voltine taxa were collected; uninterrupted surface flow appears to have characterized the site. Gatherers dominated the functional mix.

West Fork Yaak River sites

The upstream site on the West Fork Yaak River (YAKWR01) supported an invertebrate assemblage characteristic of near-pristine mountain streams. The low biotic index value (1.16) and high mayfly taxa richness (10) indicate unimpaired water quality. At least 12 cold-stenotherm taxa inhabited the site, including the mayfly *Drunella spinifera* and the stonefly *Yoraperla brevis*. Cold, clean water apparently provided the matrix for a sensitive benthic community.

There was no evidence that sediment deposition affected stony habitats; twenty "clinger" taxa and 6 caddisfly taxa were among the sampled animals. Other instream habitats also appear to have been intact, since taxa richness (40) was high and predatory taxa (15) were

abundant. Eight stonefly taxa were collected, suggesting that reach-scale habitat features were similarly undisturbed. Stable streambanks, intact and functional riparian zones, and natural channel morphology are probably indicated. Long-lived taxa were not particularly well-represented, nor were these animals abundant. A sparse semi-voltine fauna may be associated with a periodic loss of surface flow, scouring sediment pulse, or other events that abort long life cycles. The possibility that such an event recently occurred at this site cannot be ruled out. Scrapers dominated the functional composition of the assemblage; diatomaceous films may have been prolific.

Above the falls, the West Fork Yaak River site (YAKWR02) sampled for this study yielded fewer mayfly taxa (5) than expected. The biotic index value (3.11) calculated for the entire sampled assemblage was slightly elevated compared to the other sites in the area. Only 2 cold-stenotherm taxa were collected here. These findings suggest that benthic assemblages may have been challenged by subtly warmer water temperatures and/or mild nutrient enrichment.

The number of "clinger" taxa (19) was within expected limits, and the caddisfly fauna included at least 8 taxa. Sediment deposition probably did not compromise stony habitats. Taxa richness (32) and the number of predator taxa (8) were high, suggesting that instream habitats of many types were in good condition and available for colonization. Only 3 stonefly taxa were among the collected animals; low Plecoptera taxa richness may be related to disturbance of reach-scale habitat features such as streambanks, channel morphology, or riparian areas. Surface flow seems not to have been recently interrupted, since 8 semi-voltine taxa were present in the sample. A balanced functional mix incorporated all expected elements, although the proportion of filter-feeders was high compared to that of other sites in the study.

Lap Creek site

The benthic assemblage represented in the sample collected at the Lap Creek site (LAPC01) was unique among those studied; the ordination plot places the site outlying with respect to most other sites. The sample was dominated by the midge *Cricotopus nostococladius* (35% of the sampled animals). Montana protocols assign a relatively high biotic index value (6) to this insect; other biologists regard it as sensitive. The high index value, combined with the abundance of *C. nostococladius* in this sample has resulted in a cumulative biotic index value (3.84) that is elevated compared to expectations. When the biotic index calculation is made without *C. nostococladius* included, the value arrived at is 1.73, which corresponds better with the result of the other water quality indicator; mayfly taxa richness (9) at this site was high. Water quality was likely good at this site. At least 9 cold-stenotherm taxa were supported at the site, including the stoneflies *Doroneuria* sp. and *Megarcys* sp.

While both caddisfly richness (5) and the numbers of "clinger" taxa (15) collected in the sample are within expected limits, both values are slightly depressed relative to those of the other studied sites. Fine sediment deposition may affect benthic habitat availability at this site. Instream habitats appear to have been generally plentiful and diverse, however, since taxa richness (36) was high and the site supported at least 12 predator taxa. The stonefly fauna was rich (7 taxa) suggesting that reach-scale habitat features were essentially undisturbed. Six long-lived taxa were collected, but none was abundant. Despite this, it seems unlikely that dewatering or other catastrophes occurred here recently. Shredders dominated the functional mix, due to the abundance of *C. nostococladius*, which feeds exclusively on the alga Nostoc sp. Riparian inputs of large organic material were probably ample, however, since 8 shredder taxa dependent on this food source were collected. Scrapers were notably scarce here, which could support a hypothesis of sediment deposition.

South Fork Yaak River and Beaver Creek sites

Two of the 4 sampled sites in the South Fork Yaak River watershed (YAKSR03 and BEVR01) supported assemblages consistent with minimally disturbed mountain streams. Low biotic index values (0.93 and 2.14 respectively) and high mayfly taxa richness values (8, 9) characterized these assemblages. Each site yielded many cold stenotherm taxa (7, 9), including *Yoraperla brevis*, which was collected at both sites, caddisflies in the Rhyacophila Iranda Group, which were collected at the South Fork Yaak River site below Smoot Creek (YAKSR03),

and *Neothremma* sp., which was collected at the Beaver Creek site (BEVR01). Cold, clean water is indicated by these data.

Expected numbers of both "clinger" (15, 18) and caddisfly taxa (6, 8) were present in samples from both of these sites, suggesting that stony substrate habitats were uncontaminated by sediment deposition. Overall taxa richness was somewhat depressed at the South Fork Yaak River site (YAKSR03), but predator richness (9) was high there. Both metrics returned high values at the Beaver Creek site; thirty-eight taxa were collected and 10 of these were predators. Instream habitats were probably intact in both cases. Stonefly taxa richness values (4, 5) were consistent with undisturbed reach-scale habitat features, such as streambanks, riparian zones, and channel morphology. Neither site yielded many semivoltine taxa (3, 4), but the taxonomic composition of the assemblages seemed to indicate that catastrophic events were not regular occurrences in these reaches. All expected functional components were present in appropriate proportions at both sites.

In the middle reach of the South Fork Yaak River (YAKSR01), water quality indicators suggested that the reach was unpolluted by nutrients. Cold stenotherm taxa (4), however, were notably scarce here, and both the number and abundance of sensitive taxa (3 taxa, 4% of sampled animals) as well as the proportion of tolerant taxa (20%) suggested that water temperature may have been slightly elevated compared to the other sites in the study area.

Ample numbers of "clinger" taxa (16) and high caddisfly taxa richness (6) indicated that sediment deposition probably did not compromise the availability of stony benthic habitats. Taxa richness (34) was high at this site, and 13 predator taxa were collected. These findings imply diverse instream habitats. At least 4 stonefly taxa inhabited the locale; reach-scale habitat features were likely intact. Among the 8 semivoltine taxa collected here were significant numbers of *Arctopsyche grandis* and *Hesperoperla pacifica*. The presence of these animals implies that surface flow persisted year-round in this reach, and life-cycle limiting disasters did not recently occur. All expected functional components were present in the sampled assemblage.

Below Beaver Creek, the South Fork Yaak River site (YAKSR02) supported a rich mayfly fauna (9 taxa), but the biotic index value (4.01) was distinctly elevated. This high value can be attributed to the large numbers of midges present in the sample, especially *Micropsectra* sp., and animals in the Eukiefferiella Brehmi Group. Although 4 cold stenotherm taxa were collected, none were abundant, suggesting that elevated water temperatures may have affected the benthic assemblage here. Sensitive taxa richness (5) was within expected limits for a montane site, but this group was comprised of only 7 individual animals. Water quality disturbances, such as mild nutrient enrichment cannot be ruled out at this site.

Both "clinger" taxa (22) and caddisfly taxa (6) were well-represented at the site. These findings imply that stony surfaces were available for colonization, and not obliterated by sediment deposition. The high overall taxa richness (44), along with a diverse predator fauna (14 taxa) suggests that favorable instream habitat conditions were present. Only 3 stonefly taxa were collected; low stonefly diversity may be associated with unstable streambanks, disrupted channel morphology, or disturbed riparian areas. Dewatering or other catastrophic limitations to long life cycles were apparently not a factor in this reach, since 6 semi-voltine taxa were present in the sample. The functional composition was overwhelmed by gatherers; this finding is consistent with midge dominance, elevated water temperatures, and nutrient enrichment.

Pete Creek sites

The abundance of the ubiquitous midges *Tvetenia* sp. and the Eukiefferiella Brehmi Group in the sample collected from Pete Creek above Beetle Creek (PETEC02) renders the biotic index value (3.97) calculated for the assemblage higher than expected. Abundant midges can indicate elevated water temperatures or nutrient enrichment. High mayfly taxa richness (8), however, along with a diverse assortment of sensitive taxa (8) seem to indicate that water quality was good at this site. At least 7 cold stenotherm taxa were present here; these included the mayflies *Caudatella hystrix*, *Drunella doddsi*, and *Drunella spinifera*. The evidence for cold, clean water at this site is strong. Below Hensley Creek, the sampled Pete Creek site (PETEC01) was also apparently characterized by excellent water quality and cold water temperatures.

There, the dominant taxon was the cold stenothermic mayfly *Drunella doddsi,* one of 11 mayfly taxa to be identified in the sample. The biotic index value (2.00) reinforced the hypothesis of unpolluted water here.

No evidence for sediment deposition was obvious at either site on Pete Creek; both sites supported rich "clinger" (20, 23) and caddisfly (7, 8) faunae. Instream habitats were probably generally intact in both reaches, since taxa richness values were high (40, 45) and each locale supported a diversity of predator taxa (11, 15). Reach-scale habitat features were likely undisturbed; stonefly taxa richness values were high (8, 9). Long-lived taxa were well-represented at both sites in Pete Creek, precluding the possibility that dewatering or other interruptive events limited semi-voltine life cycles here. Gatherers dominated the functional composition of the site below Beetle Creek, an artifact of the midge-dominated fauna. All expected functional components were present at both sites.

Spread Creek sites

The upper site on Spread Creek (SPDUC01) supported a diverse and sensitive benthic assemblage characteristic of minimally disturbed montane streams. The low biotic index value (2.26) and high mayfly taxa richness (8) indicated unpolluted water. No fewer than 11 cold-stenotherm taxa were present at the site, and 12 of the taxa collected here exhibit high degrees of sensitivity to disturbances to both water quality and habitat. These findings strongly suggest that cold, clean water characterized the site. Downstream, in the middle reach (SPDMC01), the sampled assemblage was dominated by ubiquitous midges, especially animals in the Eukiefferiella Brehmi Group and *Tvetenia* sp. Similar to that of the upper Pete Creek assemblage, the biotic index value (4.62) calculated for these sampled animals was elevated relative to expectations for this area. However, when this evidence is balanced with the high mayfly taxa richness (9), high sensitive taxa richness (10), and the diversity of the cold stenotherm fauna (8 taxa), the abundance of these more tolerant chironomids in the sample appears to be serendipitous. Cold, clean water likely characterized this site.

Both "clinger" taxa richness values (16, 15) and numbers of caddisfly taxa (5, 5) fell within anticipated limits, suggesting that sediment deposition did not obliterate stony benthic habitats. High overall taxa richness values (41, 36) and diverse predator faunae (16, 14) are probably associated with ample available instream habitats of various types. Stonefly taxa (9, 7) were well-represented in both sampled assemblages. This finding supports a hypothesis that reach-scale habitat features such as streambanks and riparian areas were intact. Although the upper site supported at least 5 semi-voltine taxa, only 2 such taxa were collected at the lower site. Despite this, the taxonomic composition of both samples makes it seem unlikely that limiting catastrophes occurred recently in either reach. All expected functional elements were present at both locations. The lower site was dominated by gatherers.

Meadow Creek site

Abundant midges and the resultant high biotic index value (4.01) suggest that water quality may have been compromised at the sampled site on Meadow Creek. However, there is ample evidence to the contrary. At least 9 mayfly taxa were present at the sampled site. Eleven cold stenotherm taxa were collected, including *Caudatella hystrix* and *Zapada columbiana*. In spite of the large number of chironomids, cold, clean water appears to be indicated.

Sediment deposition did not appear to limit the "clinger" taxa richness (29) or the number of caddisfly taxa present (14). Fifty taxa were identified in the sample collected at the site, including 15 predator fauna. Instream habitats were probably not limited by anthropogenic disturbances. The richness of the stonefly fauna (7 taxa) implies that reach-scale habitat features were similarly undisturbed. A diversity of long-lived taxa were evident; catastrophic dewatering, sediment pulses, or toxic inputs were unlikely to have been among recent events here. The functional components included all expected groups.

Grizzly Creek site

A low biotic index value (2.42) and high mayfly taxa richness (11) strongly imply good water quality at this site. Fifteen sensitive taxa were collected; all of which were cold stenotherms. These included *Epeorus grandis* and *Ironodes* sp. Although the ubiquitous chironomid *Tvetenia* sp. was the dominant taxon, unimpaired water temperatures and unpolluted conditions appear to have characterized this site.

The rich "clinger" fauna (25 taxa) and high numbers of caddisfly taxa (9) imply benthic substrates essentially free of sediment deposition. At least 48 invertebrate taxa inhabited the site; apparently diverse instream habitats were available for colonization. Stable streambanks, intact riparian corridors, and natural channel morphology were likely, since stonefly taxa richness (8) was high here. Among the 5 semi-voltine taxa collected at the site was the caddisfly *Cryptochia* sp.; long-lived taxa suggest that surface flow was present year-round. The functional mix included all expected components in appropriate proportions.

Seventeen Mile Creek sites

Both of the sampled sites on Seventeen Mile Creek yielded benthic assemblages with high diversity, high sensitivity, and functional characteristics appropriate to minimally impaired montane streams. Low biotic index values (2.57, 2.11) and rich mayfly faunae (10 and 11 taxa) suggest that water quality was unimpaired by pollutants. Cold stenotherm taxa were abundant at both sites; downstream of Hemlock Creek (SVNTC02) 7 such taxa were collected, and at the North Fork site (SVNTC01) 10. Both sites supported significant numbers of the perlid *Doroneuria* sp., an indicator of cold, clean water.

Both "clingers" (20 and 27 taxa) and caddisflies (8 and 13 taxa) were common at these sites. Apparently, sediment deposition did not affect the fauna of these reaches. Overall taxa richness values (38, 42) were high, and predators were significant components of both assemblages; these findings suggest that undisturbed instream habitats were diverse and available. The high stonefly taxa richness values (5, 6) may be associated with undisrupted reach-scale habitat features. Dewatering, or other catastrophes were unlikely, since semi-voltine taxa (7, 6) were amply represented. These included the caddisfly *Arctopsyche grandis*, which was collected at both sites. While gatherers dominated the functional mix at the upstream site (SVTNC02), components were more appropriately distributed at the North Fork site (SVTNC01).

Habitat Assessment

Tables 5a and 5b show the habitat parameters evaluated, parameter scores and overall habitat evaluations for the 20 sites studied. Figure 5 graphically compares total habitat assessment scores for these sites. Overall habitat conditions generally received positive evaluations; all sites for which assessments were reported were categorized as optimal or sub-optimal.

Table 5a. Stream and riparian habitat assessment. These 10 sites were assessed based upon criteria developed by MT DEQ for streams with riffle/run prevalence. Yaak River Drainage, October 2002.

Max. possible score	Parameter	YAKER 01	YAKER 02	BASNC 02	YAKER 03	YAKNF 01	YAKWR 01	YAKWR 02	LAPC 01	YAKSR 03	YAKSR 01
10	Riffle development	9	10	10	7	9	8	10	9	8	10
10	Benthic substrate	8	8	9	9	10	8	10	7	7	8
20	Embeddedness	14	18	19	17	18	18	20	20	17	18
20	Channel alteration	19	20	20	19	20	20	20	20	17	20
20	Sediment deposition	15	17	19	19	18	17	20	18	16	16
20	Channel flow status	17	19	20	19	17	19	19	5	18	18
20	Bank stability	9/9	10/10	10/10	7/9	10/10	8/8	8/8	10/10	8/8	10/10
20	Bank vegetation	7/8	10/10	10/10	10/10	10/10	10/10	10/10	10/10	9/9	10/10
20	Vegetated zone	9/8	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10
160	Total	132	152	157	146	152	146	155	139	137	150
	Percent of maximum	**82%**	**95%**	**98%**	**91%**	**95%**	**91%**	**97%**	**87%**	**86%**	**94%**
	CONDITION*	OPTIMAL	OPTIMAL	OPTIMAL	OPTIMAL	OPTIMAL	OPTIMAL	OPTIMAL	OPTIMAL	OPTIMAL	OPTIMAL

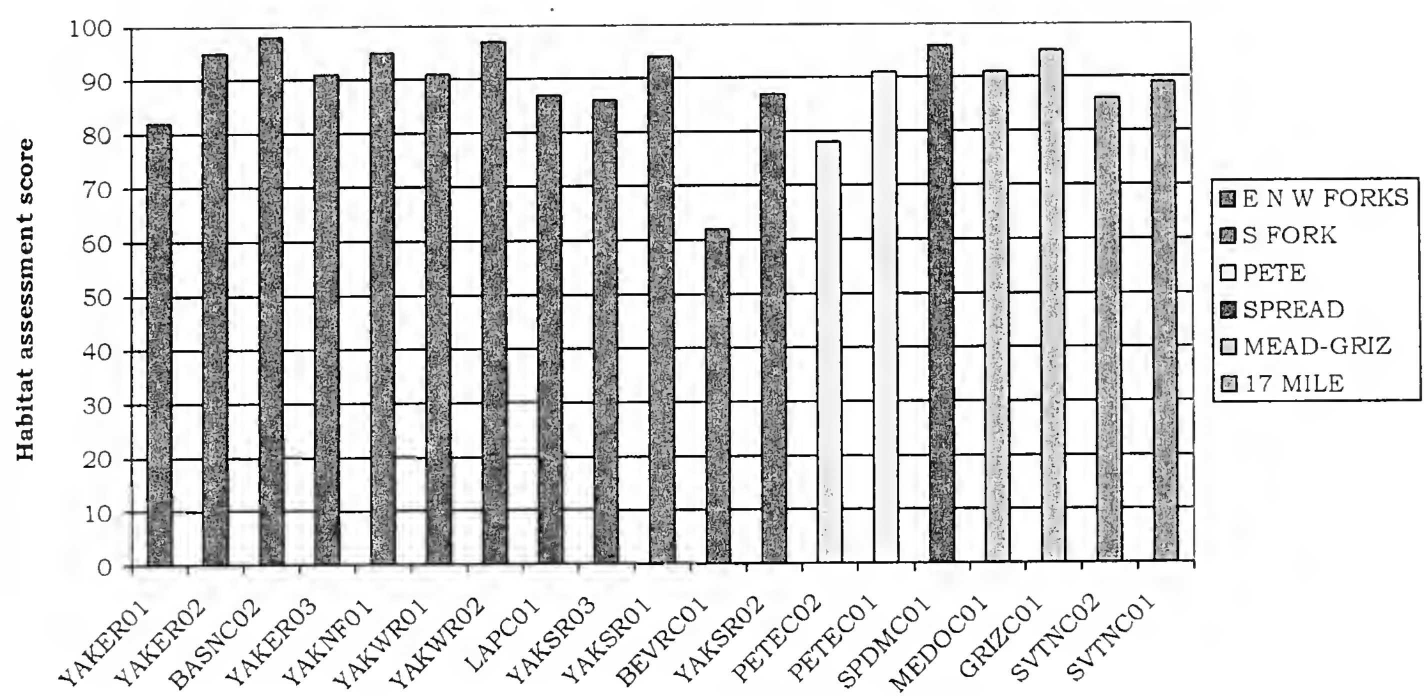
Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. (Plafkin et al. 1989).

Table 5b. Stream and riparian habitat assessment. These 10 sites were assessed based upon criteria developed by MT DEQ for streams with riffle/run prevalence. Percents of maximums for sites lacking parameter scores were calculated on a total that reflects an appropriately-adjusted maximum possible score. Yaak River Drainage, October 2002.

Max. possible score	Parameter	BEVRC 01	YAKSR 02	PETEC 02	PETEC 01	SPDUC 01	SPDMC 01	MEDOC 01	GRIZC 01	SVTNC 02	SVTNC 01
10	Riffle development	6	10	7	10	NO RECORD	10	10	10	9	10
10	Benthic substrate	5	9	7	8	NO RECORD	10	10	10	9	7
20	Embeddedness	6	17	15	19	NO RECORD	18	20	18	18	18
20	Channel alteration	19	20	15	20	NO RECORD	20	20	20	19	18
20	Sediment deposition	7	16	15	19	NO RECORD	17	18	19	15	18
20	Channel flow status	12	10	16	15	NO RECORD	18	10	15	15	18
20	Bank stability	6/6	8/9	7/7	8/9	NO RECORD	10/10	9/9	10/10	---/---	7/---
20	Bank vegetation	7/7	10/10	9/7	8/9	NO RECORD	10/10	10/10	10/10	7/8	9.5/---
20	Vegetated zone	9/9	10/10	10/10	10/10	NO RECORD	10/10	10/10	10/10	10/10	10/---
160	Total	99	139	125	145	NO RECORD ------	153	146	152	120	115.5
	Percent of maximum	**62%**	**87%**	**78%**	**91%**	------	**96%**	**91%**	**95%**	**86%**	**89%**
	CONDITION*	**SUB-OPTIMAL**	**OPTIMAL**	**SUB-OPTIMAL**	**OPTIMAL**	------	**OPTIMAL**	**OPTIMAL**	**OPTIMAL**	**OPTIMAL**	**OPTIMAL**

* Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. (Plafkin et al. 1989.)

Figure 4. Total habitat assessment compared among 19 sites in the Yaak River Drainage, August 2003. Scores are reported as the percent of maximum possible score. Scores were not reported for Site SPDUC01.



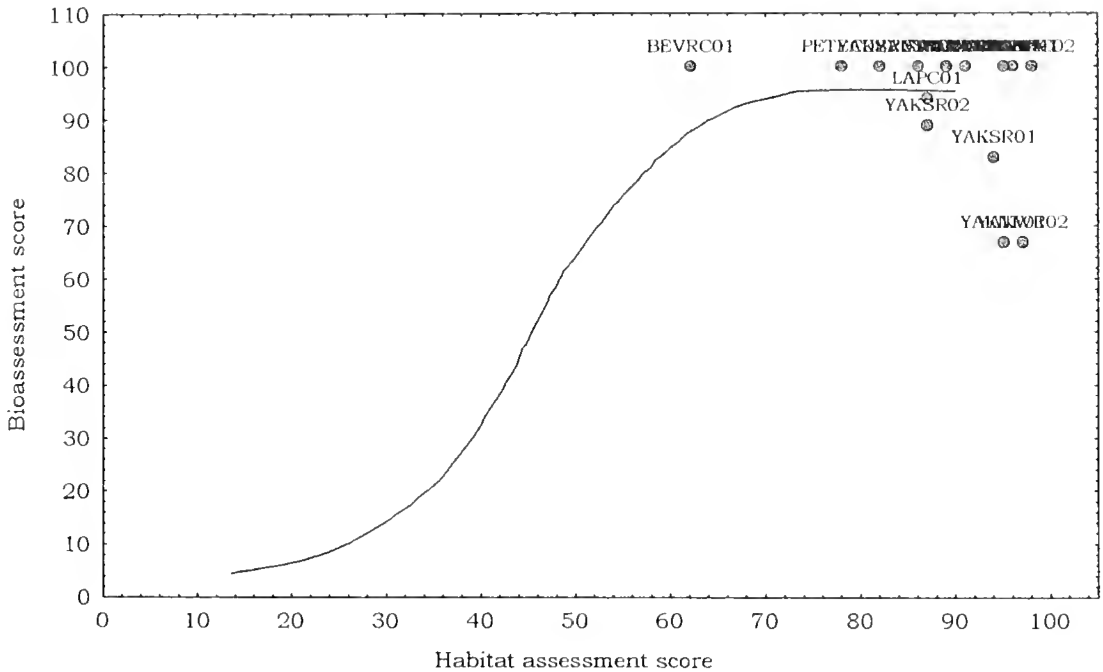
CONCLUSIONS

- Increased assemblage tolerance and abundant filter-feeders suggest slight impairment at the North Fork Yaak River site (YAKNF01). Slightly elevated water temperatures and/or mild nutrient enrichment may affect the benthic assemblage at this site.
- Interruptions of long life cycles by dewatering, sediment pulses, or other catastrophes cannot be ruled out at the upstream site on the West Fork Yaak River (YAKWR01). Few semi-voltine taxa were collected there.
- Slight impairment seems to be the appropriate assessment for the site on the West Fork Yaak River above the falls (YAKWR02). Slightly elevated water temperatures and/or mild nutrient enrichment may affect the benthic assemblage at this site.
- Some evidence of possible sediment deposition could be discerned from the data collected at the Lap Creek site (LAPC01).
- Water temperatures may have been elevated relative to the majority of sites in the area at the South Fork Yaak River site in the middle reach (YAKSR01) and below Beaver Creek (YAKSR02).
- All other sampled sites in the Yaak River watershed appeared to support sensitive, diverse invertebrate assemblages characteristic of unimpaired montane streams.

Habitat scores vs. bioassessment scores

When habitat assessment scores are plotted against bioassessment scores, the resulting figure provides an opportunity to evaluate the hypothetical relationship between habitat integrity and water quality. Both factors are critical and interactive determinants of the composition and functional integrity of aquatic invertebrate assemblages. Presumably, high quality habitat, in the absence of impairments to water quality, supports functional, diverse, and sensitive invertebrate assemblages; these are assemblages that attain high bioassessment scores. Barbour and Stribling (1991) have hypothesized that diminishing habitat quality should produce predictable diminishment of bioassessment scores, when water quality is not a further insult. Figure 6 is a plot of habitat assessment scores against bioassessment scores for the 2003 sampled assemblages of the Yaak River watershed. The red line superimposed on the plot roughly represents the hypothetical relationship between habitat quality and biotic integrity given good water quality. In this model, symbols falling in the upper right area of the graph would represent sites with high scores for both bioassessment and habitat assessment; according to this model, these would be unimpaired sites both in terms of habitat integrity as well as water quality. Most of the Yaak River watershed sites fall into this approximate area of Figure 6. Some degree of habitat degradation is hypothesized for sites located along or near the downward progression of the red line, that is, when bioassessment scores are falling predictably with decreasing habitat scores. When habitat scores remain high, but bioassessment scores are inordinately low, sites fall into the lower right hand area of the plot. According to the model, these sites support invertebrate assemblages that are impacted mostly by impairment to water quality. The plot in Figure 6 indicates that 2 sites fall into this area. They are the North Fork Yaak River site (YAKNF01) and the West Fork Yaak River site above the falls (YAKWR02).

Figure 5. Total bioassessment scores plotted against habitat assessment scores for sites in the Yaak River drainage, August 2003.



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